

CLAIMS

1 – Method for producing a workpiece, and, for example, a plate, of steel which is resistant to abrasion and whose chemical composition comprises, by weight:

$$0.35\% \leq C \leq 0.8\%$$

$$0\% \leq Si \leq 2\%$$

$$0\% \leq Al \leq 2\%$$

$$0.35\% \leq Si + Al \leq 2\%$$

$$0\% \leq Mn \leq 2.5\%$$

$$0\% \leq Ni \leq 5\%$$

$$0\% \leq Cr \leq 5\%$$

$$0\% \leq Mo \leq 0.50\%$$

$$0\% \leq W \leq 1.00\%$$

$$0.1\% \leq Mo + W/2 \leq 0.50\%$$

$$0\% \leq B \leq 0.02\%$$

$$0\% \leq Ti \leq 2\%$$

$$0\% \leq Zr \leq 4\%$$

$$0.05\% \leq Ti + Zr/2 \leq 2\%$$

$$0\% \leq S \leq 0.15\%$$

$$N < 0.03\%$$

- optionally from 0% to 1.5% of copper,
- optionally at least one element selected from Nb, Ta and V at contents such that $Nb/2 + Ta/4 + V \leq 0.5\%$,
- optionally at least one element selected from Se, Te, Ca, Bi, Pb at contents which are less than or equal to 0.1%,

the balance being iron and impurities resulting from the production operation, the chemical composition further complying with the following relationships:

$$0.1\% \leq C - Ti/4 - Zr/8 + 7xN/8 \leq 0.55\%$$

and:

$$Ti + Zr/2 - 7xN/2 \geq 0.05\%$$

and:

$$1.05xMn + 0.54xNi + 0.50xCr + 0.3x(Mo + W/2)^{1/2} + K > 1.8$$

with $K = 0.5$ if $B \geq 0.0005\%$ and $K = 0$ if $B < 0.0005\%$,

according to which the plate is subjected to a thermal quenching processing operation which is carried out in the heat for forming in the hot state and, for example, rolling heat, or after austenitization by reheating in a furnace in order to carry out the quenching:

- the workpiece or the plate is cooled at a mean cooling rate greater than 0.5°C/s between a temperature greater than AC_3 and a temperature of from $T = 800 - 270 \times C^* - 90 \times \text{Mn} - 37 \times \text{Ni} - 70 \times \text{Cr} - 83 \times (\text{Mo} + \text{W}/2)$, with $C^* = C - \text{Ti}/4 - \text{Zr}/8 + 7 \times \text{N}/8$, to $T - 50^{\circ}\text{C}$,
- the workpiece or the plate is then cooled at a core cooling rate $V_r < 1150 \times e^{p^{-1.7}}$ and greater than 0.1°C/s between the temperature T and 100°C , e_p being the thickness of the plate expressed in mm,
- the workpiece or the plate is cooled as far as ambient temperature and optionally planishing is carried out.

2 – Method according to claim 1, characterized in that:

$$1.05 \times \text{Mn} + 0.54 \times \text{Ni} + 0.50 \times \text{Cr} + 0.3 \times (\text{Mo} + \text{W}/2)^{1/2} + K > 2.$$

3 – Method according to claim 1 or claim 2, characterized in that:

$$C > 0.45\%.$$

4 – Method according to any one of claims 1 to 3, characterized in that:

$$\text{Si} + \text{Al} > 0.5\%.$$

5 – Method according to any one of claims 1 to 4, characterized in that:

$$\text{Ti} + \text{Zr}/2 > 0.10\%.$$

6 – Method according to any one of claims 1 to 5, characterized in that:

$$\text{Ti} + \text{Zr}/2 > 0.30\%.$$

7 – Method according to any one of claims 1 to 6, characterized in that:

$$C^* \geq 0.22\%.$$

8 – Method according to any one of claims 1 to 7, characterized in that tempering is further carried out at a temperature which is less than or equal to 350°C .

9 – Method according to any one of claims 1 to 8, characterized in that, in order to add titanium to the steel, the liquid steel is placed in contact with a slag containing titanium and the titanium of the slag is caused to diffuse slowly in the liquid steel.

10 – Workpiece, and in particular a plate, of steel which is resistant to abrasion and whose chemical composition comprises, by weight:

$$0.35\% \leq C \leq 0.8\%$$

$$0\% \leq Si \leq 2\%$$

$$0\% \leq Al \leq 2\%$$

$$0.35\% \leq Si + Al \leq 2\%$$

$$0\% \leq Mn \leq 2.5\%$$

$$0\% \leq Ni \leq 5\%$$

$$0\% \leq Cr \leq 5\%$$

$$0\% \leq Mo \leq 0.50\%$$

$$0\% \leq W \leq 1.00\%$$

$$0.1\% \leq Mo + W/2 \leq 0.50\%$$

$$0\% \leq B \leq 0.02\%$$

$$0\% \leq Ti \leq 2\%$$

$$0\% \leq Zr \leq 4\%$$

$$0.05\% \leq Ti + Zr/2 \leq 2\%$$

$$0\% \leq S \leq 0.15\%$$

$$N < 0.03\%$$

- optionally from 0% to 1.5% of copper,
- optionally at least one element selected from Nb, Ta and V at contents such that $Nb/2 + Ta/4 + V \leq 0.5\%$,
- optionally at least one element selected from Se, Te, Ca, Bi, Pb at contents less than or equal to 0.1%,

the balance being iron and impurities resulting from the production operation, the chemical composition further complying with the following relationships:

$$0.1\% \leq C - Ti/4 - Zr/8 + 7xN/8 \leq 0.55\%$$

and:

$$Ti + Zr/2 - 7xN/2 \geq 0.05 \%$$

and:

$$1.05xMn + 0.54xNi + 0.50xCr + 0.3x(Mo + W/2)^{1/2} + K > 1.8$$

with: $K = 0.5$ if $B \geq 0.0005\%$ and $K = 0$ if $B < 0.0005\%$,
 whose surface evenness is characterized by a deflection of less than 12mm/m, the
 steel having a martensitic or martensitic/bainitic structure, the structure further
 containing from 5% to 20% of retained austenite and carbides.

11 – Workpiece according to claim 10, characterized in that:

$$1.05 \times \text{Mn} + 0.54 \times \text{Ni} + 0.50 \times \text{Cr} + 0.3 \times (\text{Mo} + \text{W}/2)^{1/2} + K > 2.$$

12 – Workpiece according to claim 10 or claim 11, characterized in that:

$$C > 0.45\%.$$

13 – Workpiece according to any one of claims 10 to 12, characterized in that:

$$\text{Si} + \text{Al} > 0.5\%.$$

14 – Workpiece according to any one of claims 10 to 13, characterized in that:

$$\text{Ti} + \text{Zr}/2 > 0.10\%.$$

15 – Workpiece according to any one of claims 10 to 14, characterized in that:

$$\text{Ti} + \text{Zr}/2 > 0.30\%.$$

16 – Workpiece according to any one of claims 10 to 15, characterized in that:

$$C^* \geq 0.22\%.$$

17 – Workpiece according to any one of claims 10 to 16, characterized in that
 it is a plate having a thickness of from 2 mm to 150 mm and whose surface evenness
 is characterized by a deflection of less than 12mm/m.

18 – Workpiece according to any one of claims 10 to 17, characterized in that
 the hardness is from 280 HB to 450 HB and:

$$0.1\% \leq C - \text{Ti}/4 - \text{Zr}/8 + 7 \times \text{N}/8 \leq 0.2\%.$$

19 – Workpiece according to any one of claims 10 to 17, characterized in that
 the hardness is from 380 HB to 550 HB and:

$$0.2\% < C - \text{Ti}/4 - \text{Zr}/8 + 7 \times \text{N}/8 \leq 0.3\%.$$

20 – Workpiece according to any one of claims 10 to 17, characterized in that the hardness is from 450 HB to 650 HB and:

$$0.3\% < C - Ti/4 - Zr/8 + 7xN/8 \leq 0.5\%.$$